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Persistence of Postconcussional Symptoms in Uncomplicated, Mildly Head-Injured Patients: A Prospective Cohort Study

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Summary: We report the follow-up of 41 nonhospitalized subjects with uncomplicated mild head injury (MHI) and no premorbid compromising condition. At 3 months after the trauma 22 patients still complained of at least 1 postconcussional symptom (PCS) and 10 patients had 3 or more PCS. At 6 months 12 patients complained of at least 1 PCS, whereas 9 patients still had 3 symptoms or more. Patients with persistent PCS complained more of emotional symptoms. Results obtained with objective tests indicated that this group was characterized by a decreased performance on the Stroop Color Word Interference Test and a reduced tolerance to light and sound stimuli in comparison with patients with only few or no PCS. Persistent neurobehavioral deficits were correlated with scores on a postconcussive/cognitive rating scale, but not with scores on an emotional/vegetative scale. Although most patients may substantially recover after MHI, about 1 in 4 patients may persist with a residue of neurobehavioral deficits. Patients with persistent PCS should be evaluated in a multidiagnostic and objective way in order to gain a better understanding of the nature and origin of the subjective symptoms.
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It has been reported that posttraumatic symptoms and impaired performance, termed the postconcussional syndrome, may persist for weeks after mild head injury (MHI) (1). However, estimates of the frequency of the persistent syndrome vary widely from 20% up to 80% (2). This discrepancy may be due to methodological differences, such as the heterogeneity of the patient group, the definition of mild head injury, and the duration of the postinjury time (2, 3). Moreover, there are a considerable number of patients with mild concussions who are never seen by medical personnel or who are examined but not admitted to hospital. Apart from the disagreement about the frequency of postconcussional sequelae, there has been much debate over the years as to whether minor head injuries result in significant and persistent cerebral damage, and, if present, whether it is demonstrable by objective tests.

By definition, MHI patients have no neurological deficits. Therefore, neuropsychological measures have usually been used as objective criteria for the evaluation of patients with persistent postconcussional sequelae (4, 5). Persistent cognitive deficits 3 to 6 months after MHI have been reported (6, 7). The results of several other studies, however, do not indicate decreased cognitive functioning about 1 month after MHI (5, 8). It is clear that cognitive criteria are arbitrary and depend on the selection of a particular neuropsychological task. Moreover, it has been demonstrated that the cognitive deficits following MHI may be subtle and may be better detected with more

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demanding tasks of attention and information processing (7). Most studies performed so far have compared head-injured patients with nonconcussed subjects instead of directly comparing patients with and without persistent postconcussional symptoms (9). It is possible that neurobehavioral deficits may be limited to a subgroup of MHI patients, for instance, those with significant subjective disability. It is clear that studies on mild head-injured patients are beset with methodological problems. There are not only differences with respect to the definition of the patient population in terms of selection criteria and postinjury time, but there is also a lack of uniform and objective diagnostic criteria for defining a postconcussional syndrome. Moreover, the multifactorial pathogenesis of the postconcussional syndrome warrants a multidiagnostic approach with objective tests (9). MHI patients with evidence of a premorbid or traumatic compromising condition have to be excluded in order to focus on a homogeneous group of patients with clearly defined, uncomplicated MHI.

It was therefore the first aim of our study to prospectively examine a cohort of previously healthy subjects who sustained an uncomplicated MHI in order to assess the rate of symptom persistence in this selected population. The second aim of the study was to test the hypothesis that there is an objectiveable basis for the subjective disability of patients with persistent postconcussional symptoms (PCS). Because of the heterogeneous nature of the postconcussional syndrome, we examined the patients with a multidiagnostic test battery using measures for different neurobehavioral functions, that is, a psychophysical measure of visual and acoustic hyperesthesia, a cognitive measure of attention, and two behavioral rating scales (a postconcussional/cognitive scale and an emotional/vegetative scale).

MATERIALS AND METHODS

Subjects

Patients seeking medical attention within an hour of a mild head injury and who did not require hospital admission were invited to participate in the study. On admission all patients were investigated neurologically and a radiograph of the skull was made. MHI was defined as a concussion with a posttraumatic amnesia not exceeding 60 minutes, a period of unconsciousness of less than 15 minutes, and a Glasgow coma score of 15 on admission. The length of time unconscious was reported by significant others or, in a very few cases, by the patients themselves when no other accurate source of information was available. In addition, the criteria for inclusion in the study (i.e., an uncomplicated MHI) included the absence of any of the following conditions or factors: evidence of a focal neurological deficit; a skull fracture; a serious noncerebral traumatic complication (including an orthopaedic injury); intoxication at the time of the trauma; a history of a previous head injury, or a history of preexisting emotional problems. Evidence of a history of preexisting emotional problems was present if one of the following criteria was met: treatment by a psychiatrist or psychologist within the last 3 years, the use of psychotropic medication, or a history of an adjustment reaction to a psychosocial stressor.

From a consecutive series of 131 patients aged 15 and older, 31 patients did not live close enough to allow follow-up assessments, and 29 patients were not willing to participate in the study (71 patients were willing to participate in the study). Of this group, 46 patients (23 females and 23 males) fulfilled the above-mentioned criteria of an uncomplicated MHI without a premorbid compromising condition. Patients were assessed 4 times after the injury. The initial examination was performed within 6 to 14 days after the injury, with follow-up assessments at 5 (4–6) weeks, 3 months (13–15 weeks), and 6 months (22–28 weeks). Three patients dropped out at 5 weeks, and two patients at 3 months: 41 patients completed the study. The causes of the injury were traffic (33), falls (6), fights (1), sports (5), and accident at work (1) (N = 46). Patients with uncomplicated MHI were matched for age and sex with 43 nonconcussed control subjects who were recruited from a pool of healthy volunteers in order to obtain normative data for the applied neurobehavioral tests. The nonconcussed subjects were not serially tested. Table 1 summarizes the major demographic characteristics of the patient groups. Of the 29 patients who refused to participate, 21 were males and the majority (N = 18) were intoxicated at the time of the trauma. In comparison with the participating patients, this group was

TABLE 1. *Age and educational level of the different patient groups*

Patient group	N	Age	Education
Uncomplicated MHI patients	46	28.3 (14.9)	5.0 (0.8)
Uncomplicated MHI patients with at least 3 PCS at 3 mo.	10	29.9 (12.3)	4.7 (0.5)
Uncomplicated MHI patients with no PCS at 3 mo.	19	23.6 (12.6)	5.2 (0.9)
Uncomplicated MHI patients with at least 3 PCS at 6 mo.	9	31.2 (11.7)	4.5 (0.6)
Uncomplicated MHI patients with no PCS at 6 mo.	29	25.6 (14.6)	5.1 (0.9)
Control subjects	43	29.2 (14.2)	4.7 (0.9)

Mean data are presented (±SD). The 7-point scale of Verhage (10) represents 7 different levels of educational achievements based upon the particular system of the Dutch scholastic system.

less educated (4.1 ± 0.5 levels (10): the scale of Verhage is a 7-point scale based upon both the duration and the level of education in the Netherlands) and were somewhat younger (23.5 ± 8.5 years). In addition, fighting was the cause of the trauma in 14 cases. It needs to be stressed that the present results concern a selected population of uncomplicated and unhospitalized MHI patients. Hospitalized patients, including patients with more systemic injuries, alcohol intoxication, or neurological deficits, were not included. The group of patients that refused to participate consisted mainly of younger intoxicated males. This means that this group of young males is underrepresented in the present study. Some of the data obtained with the specific diagnostic tests at 10 days and 5 weeks are reported elsewhere (11). The study was approved by the ethical council of the University Hospital, and all subjects gave their informed consent.

Procedure

At each assessment the concussed subjects completed two rating scales, one consisting of postconcussional/cognitive and the other of emotional/vegetative complaints. In addition, patients were examined by using an objective test of visual and acoustic hyperesthesia and a cognitive measure (Stroop Color Word Test).

Postconcussional Symptom Checklist

It was one of the goals of the study to investigate the value of two newly developed behavioral rating scales. Therefore, a checklist of standard postconcussional symptoms (PCS) was completed by the physician for a clinical assessment of the patients, which included items such as headache, dizziness, nausea, difficulties with concentration and memory, fatigue, sleep disturbances, and blurred vision. As these symptoms also occur in healthy individuals (8), the symptoms were scored for the absolutely or relatively increased appearance after the injury in comparison with the pretraumatic condition.

Patients with PCS are defined in this paper by an increased appearance of above-mentioned symptoms (see also ref. 2). Generally, headache is the most frequently reported symptom (5). We divided the patients into three groups at each assessment: a group who still complained of at least 3 PCS (often a combination of headache, fatigue, cognitive problems, or dizziness), a group with only 1 to 2 PCS (mainly headache), and a group that had no symptoms at all.

Patterns of Behavioral Dysfunction

A 26-item questionnaire that consisted of questions about a number of postconcussional and cognitive-energetic complaints as well as of a series of emotional and psychovegetative complaints was filled in by 71 consecutively admitted MHI patients who were willing to participate in the prospective study about 10 days after the trauma. These data were used for the construction of rating scales (12). In short, the first step was to select different subgroups of intercorrelated variables by means of factor analysis. The second step was to assess the internal consistency of the items in order to construct a reliable scale. Consequently, principal components analysis [with varimax rotation (13)] was performed on the total item pool and revealed two factors (Table 2). To minimize misspecification, factor loadings were considered relevant if they had achieved a value of ±0.45 or more.

Factor I (postconcussional/cognitive complaints) consisted of 11 items evaluating cognitive-energetic and traditional postconcussional symptoms. Factor II (emotional/vegetative complaints) included 14 items of rather aspecific psychovegetative functional symptoms as well as items of depression and emotional lability (see Table 2). The internal consistency of the two groups of items was calculated according to the classical test theory of item analysis (Cronbach's alpha). Cronbach's alpha for the first group (11 items) was 0.92 and was 0.86 for the second group of 14 items. Therefore, these two groups of items may both be considered to form a scale (14). Total scores were calculated by summing the original scores on the selected items per factor. The response to each question was scored according to the severity and intensity of the complaints: 1 = no, 2 = somewhat, 3 = moderately or regularly, and 4 = much or very often.

Assessment of the Magnitude of Tolerance for Light and Sound

Light and sound stimuli of different intensities were presented by using an IBM-XT personal computer (11). The computer contained a parallel interface and controlled both a tone generator (calibrated for 1,000 Hz) with varying amplitude and a 50-W tungsten-halogen lamp. The tone generator was connected to a pair of ATH-910 earphones (Audiotechnica) with noise-reducing caps. The lamp was placed on a round tube. Each subject was seated so as to look into the center of the light source at 1-m distance from their eyes. Five intensities of sound and light were chosen on the empirical basis that they could be distinguished clearly by the human ear and eye (57, 71, 81, 89, and 95 dB for sound, and 440, 500, 600, 1,000, and 1,500 lux for light). Each of the five intensities was randomly presented 8 times; there were separate sessions for the two types of stimuli. Each stimulus was pre-

TABLE 2. *High loading items on the varimax rotated factors*

Postconcussive-cognitive scale		Emotional-vegetative scale	
Headache	0.68	Restless	0.46
Decreased work performance	0.76	Tense feeling on chest	0.45
Intolerance to light	0.60	Problems with digestion	0.45
Small efforts require much energy	0.80	Flushes easily	0.52
Trouble concentrating	0.64	Feeling short on breath	0.59
Trouble being interrupted by others	0.63	Feeling faint	0.58
Tires easily	0.67	Heart palpitations	0.75
Intolerance to noise	0.65	Depressed	0.62
Trouble doing things simultaneously	0.58	Wet hands	0.50
Dizzy	0.70	Crying more easily	0.53
Irritability	0.57	Irritability	0.50
		Decreased libido	0.60
		Loss of initiative	0.51
		Being easily overwhelmed by problems	0.64

Factor I reflects postconcussive and cognitive complaints, and factor II lists more emotional and vegetative items. Only items with a factor loading greater than 0.45 are listed.

sented for 4 seconds, and was followed by a constant interval. The rise-fall time of the physical stimulus was longer than 10 ms. The interval was kept constant in order to achieve a relative constancy in individual habituation processes (for sound 6 seconds and for light 12 seconds; see also ref. 15). During this interval, the subject was asked to evaluate the preceding stimulus on a 7-point rating scale, ranging from totally tolerant/bearable (score: s0), via very mildly (s1), mildly (s2), moderately (s3), moderately to severely (s4), severely (s5), to totally unbearable (s6). The response was given by pressing a button on a 7-point keyboard. After the session, the median tolerance value per subject was calculated for each intensity level.

Test Material: Stroop Test

The Stroop Color Word Interference Test (16) used in our study is a version available commercially in The Netherlands (Swets & Zeitlinger, Lisse, 1971). The test consists of three parts, with each part being presented on a 21×29.5-cm sheet of paper. Ten lines are printed in each subtask with 10 items per line. The test examines the speed at which 100 color names (yellow, green, red, and blue) are read (subtask I) and the speed at which 100 colored spots are named (subtask II). Subtask III again involves 100 color names, but the color names are printed in inappropriately colored ink. The naming of the printing ink of the words is taken as the test variable. The Color Word Interference score is obtained by subtraction of the time needed for subtask II from the time needed for subtask III (III − II) and was used as the cognitive parameter in the present study. This interference measure can be taken as a measure of selective attention (17).

Statistical Analysis

The two highest intensities (95 dB for sound; 1,500 lux for light) were chosen as the principal parameters in the present study. Because of the ordinal level of the tolerance scale, ranks over all observations were calculated (18) and analyzed by analysis of variance (ANOVA) with the factor "group" (patients with no, 1–2 or 3 or more PCS at 3 or 6 months). Duncan's multiple range tests were used as post hoc tests (13). There were no significant differences in educational level [$F(1, 40) = 1.54$; NS] and age [$F(1, 40) = 1.58$; NS] between the PCS groups. Therefore, the data on the Stroop Test were similarly analyzed with ANOVA. Chi square tests were performed between prognostic variables such as sex, education, and the persistence of PCS at 3 and 6 months after the trauma. Multiple regression analysis was used to investigate the relationship between individual scores on the two behavioral rating scales and performance on the objective tests. Normative data for tolerance to light and sound, performance on the Stroop Test, and scores on the two rating scales were obtained from nonconcussed subjects.

RESULTS

Persistent Postconcussional Symptoms in Patients with Uncomplicated Mild Head Injury

The results of the tests are presented in Table 3. The proportion of patients with PCS at 3 months was 22/41 (54%); 12 subjects had 1 or 2 symptoms and 10 had 3 symptoms or more. Headache was the most common symptom reported, followed by fatigue, dizziness, and problems with concentration. Symptoms

TABLE 3. *Frequency distribution of postconcussive symptoms for the group of uncomplicated MHI patients at the four follow-up assessments*

Symptom	10 days N = 46	5 weeks N = 43	3 months N = 41	6 months N = 41
Headache	34 (74)	24 (56)	17 (41)	12 (29)
Nausea	9 (20)	4 (9)	3 (7)	2 (5)
Fatigue	33 (72)	24 (56)	16 (39)	8 (20)
Dizziness	28 (61)	19 (44)	12 (29)	9 (22)
Decreased memory	20 (43)	16 (37)	10 (24)	8 (20)
Decreased concentration	25 (54)	18 (42)	11 (27)	10 (24)
Insomnia	19 (41)	14 (33)	8 (20)	8 (20)
Blurred vision	6 (13)	3 (7)	0 (0)	1 (2)

The data are based on relative increase relative to pretraumatic baseline level.
Absolute numbers are given with percentages in parentheses.

were experienced by 12 patients 6 months after the trauma (N = 41); 3 patients had 1 or 2 symptoms and 9 patients had at least 3 symptoms. Headache was again the most frequently mentioned symptom, followed by problems with concentration and dizziness. The mean time off work in the group was 3.2 weeks (±1.7), with a maximum of 8 weeks. Although 9 patients with more than 3 PCS at 3 months had resumed their work, all of them experienced problems, with one patient being forced to stop working for a second time. There was no significant relation between the incidence of PCS and the factors of sex, age, educational level, and duration of posttraumatic amnesia (shorter or longer than 15 minutes).

Behavioral Dysfunction Scales

The scores on the two behavioral rating scales are depicted in Fig. 1. The data of the group as a whole revealed a steady decline on the two scales with the passage of time postinjury. It was striking that patients who had at least 3 persistent symptoms at each time point tended to have higher scores on the emotional/vegetative scale as the time postinjury increased.

Visual and Acoustic Tolerance: Results on the Different Tests in Relation to the Presence of Symptoms at 3 and 6 Months

Mean data for each test per group and time point are presented in Table 4 together with ANOVA *F* values for overall "group" effects. Significant "group" effects were found for tolerance to sound both at 3 months and at 6 months as well as for tolerance to light at these two time points (Table 4). Post hoc testing indicated that patients with 3 or more PCS at 3 and 6 months had a significantly decreased tolerance to light and sound in comparison with patients with 1 or 2 or no PCS at the same time points. In contrast, there were no significant differences in tolerance to light or sound between patients with 1 or 2 PCS and patients without symptoms, except at 3 months when the patients with 1 or 2 PCS had a lowered tolerance to sound than the patients without PCS (Table 4). With respect to the levels of tolerance to light and sound in nonconcussed subjects, the proportion of patients with a considerable to complete lack of tolerance (score: 5–6) for 95 dB was 18/46 at 10 days ($\chi^2 = 17.9$; $p < .001$), 11/43 at 5 weeks ($\chi^2 = 9.7$; $p < .01$), 7/41 at 3 months ($\chi^2 = 5.3$; $p < .05$), and 6/41 at 6 months ($\chi^2 = 4.2$; $p = .06$) versus 1/43 of nonconcussed controls. For 1,500 lux light these proportions

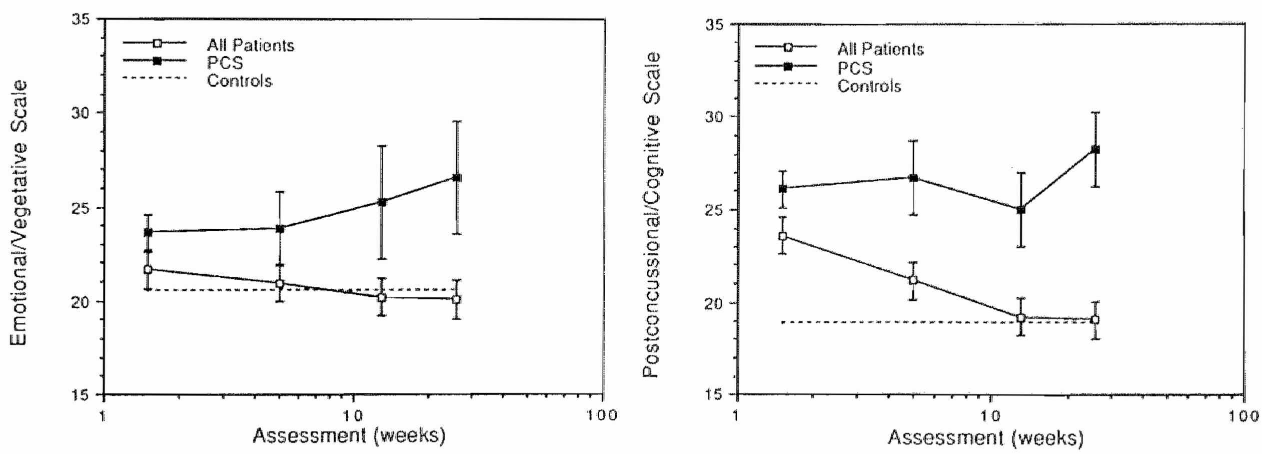

FIG. 1. Mean scores on the two rating scales at the 4 follow-up assessments for the total group of patients with uncomplicated MHI, patients with 3 or more PCS (=PCS group) at each time point and normative data for of nonconcussed subjects. The two rating scales concern subjective complaints. The normative groups of controls was formally tested on only one occasion and the line presented reflects a projection.

TABLE 4. *Mean data of the levels of tolerance to sound (95 dB) and light (1,500 lux), and performance on the Stroop Color Word Test*

	no PCS (N = 19)	1–2 PCS (N = 12)	3 PCS or more (N = 10)	ANOVA *F* values
Patients with uncomplicated MHI 3 months after the trauma				
Tolerance to light and sound				
95 dB	2.22/1.26ab	3.25/1.73b	3.95/1.36a	5.0*
1,500 lux	2.23/1.48a	2.75/1.42b	4.15/1.73ab	4.7*
Stroop Test				
Subtask I	40.75/5.78	41.02/10.12	49.00/9.43	
Subtask II	50.36/7.74	54.32/12.11	60.84/12.18	
Subtask III	72.82/14.01	76.12/14.63	99.49/19.81	
III – II	21.81/9.98a	21.72/8.23b	38.52/12.71ab	9.9***
Patients with uncomplicated MHI 6 months after the trauma				
	no PCS (N = 29)	1–2 PCS (N = 3)	3 PCS or more (N = 9)	ANOVA *F* values
Tolerance to light and sound				
95 dB	2.10/1.03a	2.00/1.84b	4.62/1.69ab	9.2***
1,500 lux	2.18/1.27a	2.00/1.56b	4.56/1.68ab	9.3***
Stroop Test				
Subtask I	38.61/4.99	38.40/4.20	53.75/13.88	
Subtask II	48.59/6.38	52.55/7.74	62.83/10.02	
Subtrask III	69.11/10.47	75.51/12.86	100.77/19.88	
III – II	20.25/7.14a	22.04/10.11b	35.56/12.44ab	10.2***

The difference score (III – II) represents the Color Word Interference measure. Means are presented with SD. Letters a and b indicate a significant difference between the two groups, as assessed by post hoc testing. The grouping variable refers to patients with no PCS, 1 or 2 PCS, or at least 3 PCS at the respective time points.
* $p < .05$; ***$p < .001$.

were 18/46 (χ^2 = 15.2; $p < .001$), 10/43 (χ^2 = 6.2; $p < .05$), 8/41 (χ^2 = 4.4; $p < .05$) and 6/41 (χ^2 = 2.4; NS) at the same time points, against 2/43 of the controls.

Stroop Test Results

Analysis of variance of the Stroop Color Word Interference measure revealed a significant "group" effect at both 3 and 6 months (Table 4). Post hoc tests indicated that patients with at least 3 PCS were significantly more susceptible to interference (higher interference scores) than patients with no or less PCS. In contrast, there was no significant difference in the interference measure between the group of patients with only 1 or 2 PCS versus patients with no PCS at 3 or 6 months after the injury.

With respect to normative data in nonconcussed subjects, there were 7 of the 10 patients with at least 3 PCS at 3 months postinjury who had scores lower than the 10th percentile in healthy volunteers of similar age and educational level (χ^2 = 7.5; $p < .01$). This figure was 6 of 9 patients at 6 months after the injury (χ^2 = 6.5; $p < .05$). In contrast, there was only 1 patient with a similarly decreased level of performance in either group with only 1 or 2 or no PCS (χ^2 = 0.01; NS).

Relationship Between Scores on Behavioral Rating Scales and Objective Testing

Finally, we studied the relationship between the scores on the two behavioral scales and performance on the objective tests for the combined MHI groups (N = 41). Multiple regression analysis revealed that the scores on the cognitive/postconcussional scale were significantly related to decreased performance on all objective tests (sensory and acoustic hyperesthesia, Stroop Interference measure) at 6 months after the trauma. In addition, scores on the postconcussional/cognitive rating scale predicted performance in the Stroop Color Word Interference Test at 3 months after the injury. In contrast, scores on the emotional/vegetative scale were not significantly related to performance on the three objective tests at the two time points (Table 5).

DISCUSSION

Studies on MHI patients performed so far have mostly been limited to the study of a single diagnostic

TABLE 5. *Results from the multiple regression analysis*

	Regression model		Coefficient postconcussional/ cognitive scale	Coefficient emotional/ vegetative scale
	$F(2, 39)$	Intercept		
3 months after the trauma				
95 dB	$F = 6.05$	0.39	0.10 (t = 1.64, p = 0.11)	0.02 (t = 0.29, NS)
1,500 lux	$F = 4.36$*	0.55	0.12 (t = 1.59, p = 0.12)	0.0 (t = 0.02, NS)
Stroop Test (III − II interference)	$F = 4.31$*	14.86	1.36 (t = 2.48*)	−0.73 (t = −1.23, NS)
6 months after the trauma				
95 dB	$F = 21.64$***	−0.62	0.19 (t = 3.73***)	−0.01 (t = −0.30, NS)
1,500 lux	$F = 16.50$***	0.47	0.24 (t = 4.48***)	−0.11 (t = −1.90, NS)
Stroop Test (III − II interference)	$F = 3.72$*	19.07	0.83 (t = 2.24*)	−0.54 (t = −1.37, NS)

Analysis between performance on the objective tests (tolerance to sound and light, and performance on the Stroop Color Word test) and scores on the two behavioral rating scales (regressors) for the combined patient groups (N = 41) at 3 and 6 months after the trauma. Regression coefficients are presented together with the corresponding t value and significance level. The regression analysis is based upon simultaneous entering of the two variables in the model. The correlation between the scales is 0.68 and 0.72 at 3 and 6 months, respectively.

* p < .05; ***p < .001.

measure, and few studies have reported the serial testing of patients with MHI (4, 5, 7). Consequently, our knowledge in this area is still quite fragmentary and not adequate to reconcile certain points of contradictory information that have begun to emerge (3). In our study we sought to increase our understanding of the postconcussional effects of MHI by looking at neurobehavioral functioning from several perspectives. The primary purpose of the study was to evaluate the neurobehavioral effects and clinical course of uncomplicated mild head injury. With respect to the generalizability of the results, the conclusions drawn are restricted to this selected population of nonhospitalized patients with an uncomplicated MHI.

There is disagreement about the frequency of postconcussional sequelae. We found that about one-fourth of our nonhospitalized patients with uncomplicated MHI who did not have a premorbid compromising condition had 3 or more PCS at 3 and 6 months.

With respect to the question whether there is an objectiveable basis for the subjective complaints, results obtained with objective tests indicated that the patients with 3 or more persistent PCS tolerated intense sound and light stimuli significantly less well than control patients and nonconcussed subjects. This is in accordance with the findings of Jonsson et al. (19), who found that MHI patients with persistent symptoms 3 months after injury had a reduced ability to endure intense light and sound stimuli in comparison with neurotic control patients and healthy nonconcussed subjects.

The Stroop Color Word Interference Test has been used to measure selective attention in patients with head injury (17). Results consistently indicate that head-injured patients have no specific difficulty in focusing on the color dimension of the ambiguous stimuli when data are aggregated at a group level without reference to the persistence of PCS (20, 21). In contrast, McLean et al. (22) found a significant interference effect on the Stroop Test only in the subacute stage postinjury. These studies have compared head-injured patients with nonconcussed subjects instead of directly comparing patients with and without PCS. We found that patients with 3 PCS or more at 3 and 6 months after MHI were disproportionally slower at the interference task than the patients with no or fewer PCS.

Patients with persistent sequelae after the first weeks of recovery following MHI have been the source of controversy regarding the organic versus psychogenic etiology of their sequelae (9). Recent reports favor a multifactorial explanation, in which persistent PCS would result from an interaction between organic and psychological factors (3, 9). A surprising finding was that the MHI patients with 3 or more persistent PCS complained significantly more of aspecific emotional and vegetative symptoms than patients with fewer or no symptoms. However, it was found that only the scores on the postconcussional/cognitive scale were significantly related to poorer performance on the objective tests at 6 months after the injury. In contrast, scores on the emotional/vegetative scale did not predict performance on these tests.

An important question is whether or not the lower cognitive performance of these patients was caused by the injury or was already present before the injury. Given the lack of premorbid cognitive information we cannot draw a firm conclusion. However, patients with a neuropsychiatric history were excluded from the study. In addition, 4 of the 10 patients with 3 PCS or more at 3 months after the injury were working in responsible jobs, two patients were successful high school students, 2 persons performed semiskilled work, and the remaining two subjects were active housewives. Lastly, given the duration of the follow-up (6 months), the structure of the Dutch Social Security system is such that the results are unlikely to be affected by considerations of compensation.

Apart from possible premorbid biasing factors, posttraumatic psychological distress and comorbid factors, such as chronic headache or depression, need to be considered as well. None of the patients developed symptoms of a posttraumatic stress syndrome or depressive disorder. In addition, the symptomatic patient group with only 1 or 2 PCS (mainly headache) did not differ in their mean test scores from the asymptomatic patient group. Nevertheless, it may be clear that multiple factors may contribute to the pathogenesis of the postconcussional syndrome (9, 24). As in other studies, we were not able to predict the persistence of PCS on the basis of age, sex, PTA, or educational level (7, 23). Although there are reports that older patients are at greater risk (2), the absence of a significant difference in our study could be due, in part, to the small number of patients involved. Although we applied a multidiagnostic test battery in our study, the scope of assessment still remains limited. Further research should be aimed at a more integrated approach, using a combination of cognitive, psychological, and neurophysiological or neuroimaging measures, to investigate more fundamental mechanisms of postconcussional pathogenesis.

It can be summarized that about 25% of the patients with uncomplicated MHI and without premorbid abnormalities or acute traumatic complications were still subjectively disabled 3 and 6 months after the injury. The findings indicate that patients with subjective impairments may have demonstrable deficits on neurobehavioral tests.

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